Radio Astronomy

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This article reports on the activities of the Deep Space Network in support of Radio and Radar Astronomy operations during January and February 1980. It also reports on the objectives, results, and implications of the Pulsar Rotation Constancy Experiment sponsored by OSS.

I. Introduction

Deep Space Network 26-meter, 34-meter, and 64-meter antenna stations are utilized in support of experiments in four categories: NASA OSS, NASA OSTDS, Radio Astronomy Experiment Selection (RAES), and Host Country.

II. Radio Astronomy Operations

A. NASA OSS Category

On 17 February, the Goldstone 26-meter station and the Tidbinbilla 64-meter station supported for five hours the first in the resumed series of Alsep/Quasar VLBI observations. Support for the Jupiter Patrol observations of Planetary Radio Astronomy has continued at prior levels at the Goldstone and Madrid 26-meter antenna stations. Similarly, the Pulsar Rotation Constancy experiment has enjoyed a consistent level of support. The following is a brief summary of the status of this activity.

Pulsar Rotation Constancy (OSS 188-41-52-09-55)

1. Observational objectives. To measure the phase of the pulse train from these naturally occurring radio sources at regular intervals, e.g., intervals which are short compared with the time scale of known changes in the pulse train.

One unexpected benefit of being able to measure the average observed pulse shape at Deep Space Network frequencies (particularly 13 cm) allows measurement of fluctuations in pulse energy on intermediate time scales, possibly due to interstellar inhomogeneities.

2. Observed results

(1) Known pulse periods vary from the 33 milliseconds of the Crab nebula pulsar to as long as 4 seconds.

(2) Period of the pulse is slowly growing in time, i.e., $\dot{P}$ of the "ripple" is always positive. No radio pulsars have been observed with a significant negative first derivative.

(3) There have been observed steps in the period, where the period suddenly decreases slightly by parts in 10^6 (Vela pulsar) and parts in 10^8 (Crab pulsar).

(4) There is another level of observed activity consisting of short term positive and negative changes in pulse period of the order of parts in 10^{10}. This is known as "timing noise."

(5) If the pulsar model is well maintained, then model parameters (e.g., proper motion) can be resolved over appropriate time periods.

3. **Implications.** The range of periods observed is best explained by remnants of earlier Super Nova Explosions. One of the phenomena observed, i.e., the consistent slowing down of the pulsar, may indicate some measure of drag on the object and may be linked with the pulse generation process.

Current thinking is that a pulsar object is a neutron star, but is a neutron star really solid neutron? Or is it a composite structure and, if so, what are the components? It is currently hypothesized that there are at least two components: a crust, composed mostly of iron, and a neutron interior. This is predicated by the steps exhibited in the epoch. These components may be weakly coupled, may have different spin rates, and at the "step" time it could be that the crust speeds up because it collapses slightly while the inner core takes time to catch up. Question: Is there yet another component? The interaction between the two or more components is more complex than was previously thought and requires a lot more work. Of particular interest is the possibility of being able to predict the next epoch step of the Vela pulsar, say, to within two months.

The long-term tracking requirements of these objects are similar to spacecraft requirements so that stability of equipment and personnel expertise and the availability of time itself all contribute significantly to a successful observing program.

B. NASA OSTDS Category

Support for activity in this category is limited to Planetary Radar Imaging, and during the period of this report support has been at a very high level. Approximately 10 hours every 4 days has been provided at the Goldstone 64-meter antenna station, utilizing the 400-kW 13-cm transmitter and advanced systems receivers and radar correlator in observations of the planet Mars through its current opposition (26 February). On 29 January, with very short notice, the Goldstone 64-meter facility was made available to attempt radar imaging of the comet Bradfield, 1979L, a singular, exciting opportunity. Almost one hour of data was gathered from a 4-hour pass.

C. RAES Category

1. **RA 169.** On 1 February, the Goldstone and Tidbinbilla 64-meter stations supported VLBI observations of the compact radio nuclei of normal and extended galaxies and quasars for five hours.

This experiment was the first in a series of observations designed to traverse the celestial sphere over a period totalling 25 hours, with the object of observing previously detected sources at 3.8 cm and searching for hitherto undetected sources at 13 cm.

At 3.8 cm the resolution obtainable from this baseline is about three times greater and the sensitivity about four times greater than on U.S. baselines. At 13 cm the resolution is comparable with that of U.S. baselines at 3.8 cm, but the sensitivity is an order of magnitude better.

2. **RA 171.** On 2 and 3 February, for a total of 16 hours, several observatories, including Owens Valley Radio Observatory, Jodrell Bank Radio Observatory, and the Goldstone and Madrid 64-meter antennas, supported VLBI observations of M87 and NGC 6251.

These observations fulfill the requirements as described in the experimenters' proposal, which is now transferred to the completed file. Publication of the results will be forthcoming after the data are analyzed.

3. **RA 176.** On 26 and 27 February, the Goldstone and Madrid 64-meter antenna stations combined with the Max Planck Institute, Bonn Observatory, for a total of 23 hours to observe the Twin Q.S.O. 0957, + 56 A, B. This experiment was first supported in November 1979, and, at first, it was thought to have been unsuccessful due to a precessed position error in the source coordinates. However, good science data were obtained at 13 cm on the Bonn-Goldstone baseline, and this latest observation was designed to replicate this with the increased sensitivity available with the Mark III Data Acquisition System.

The Deep Space Network does not yet have the Mark III available on a regular basis, but a loan to the Goldstone facility from Owens Valley Radio Observatory was arranged, enabling both Mark II and Mark III data to be recorded at the California station, supported with Mark II data in Spain and Mark III data in Germany. Also, on this occasion during the last 90 minutes of the observation, the stations were reconfigured to provide some data at 3.8 cm. The data reduction and analysis and results publication are eagerly awaited.

D. Host Country Category

1. **Australia.** During this period host country activity in Australia has been, almost exclusively, pulsar observations at Orroral Valley at the rate of approximately 10 hours support per week.

2. **Spain.** There has been no host country activity in Spain during this period.